The specification problem in regression analysis

den Butter, F.A.G.; Verbon, H.A.A.

published in
International Statistical Review
1982

International Statistical Review, **50** (1982), pp. 267–283. Longman Group Limited/Printed in Great Britain

The Specification Problem in Regression Analysis

F.A.G. den Butter and H.A.A. Verbon

Econometric and Special Studies Section, De Nederlandsche Bank N.V., P.O. Box 98, 1000 AB Amsterdam, The Netherlands

Summary

This paper reviews a number of statistical and economic-theoretical arguments in the specification of a regression equation. Special attention is paid to the specification choice of levels versus first differences and levels versus logarithms. From the literature some *ad hoc* arguments concerning these choices have been summed up. Attention is also paid to the usefulness of Box–Jenkins time series analysis and the specification analysis of Hendry, Mizon *et al.* in choosing between a specification in levels and first differences. The theoretical plausibility of regression results serves as a limiting condition. Examples are therefore given in which theory prescribes the form of the equation. Finally a review is presented of the specification in a number of models.

Key words: Box–Cox transformation; Economic theory; First differences; Log linear models; Macro-economic models; Misspecification tests; Specification tests; Stochastic difference equations; Transfer functions.

1 Introduction

The general form of a regression equation describes the relation between a dependent variable y and a vector of explanatory variables $\vec{x}$:

$$g(y, \vec{x}) = 0.$$

For an empirical determination of the relationship between y and $\vec{x}$, this regression equation needs to be specified further. In the specification process all kinds of assumptions are made, whether implicitly or not, on how $\vec{x}$ influences y. For example, y is nearly always described as an explicit function of $\vec{x}$:

$$y = f(\vec{x}).$$

On the way from this form to the specification to be estimated, the following questions may arise:

(1) Can the relation between y and $\vec{x}$ be described linearly in the coefficients?
(2) If so, what will be the functional form: linear, log linear, semi-log or something in between (e.g., square root transformation, scaling)?
(3) How are lag mechanisms described?
(4) How will the error term be introduced?

With respect to questions (1) and (4), suppose that y is fully described by an unknown function ϕ of $\vec{x}^*$

$$y = \phi(\vec{x}^*), \tag{1.1}$$

where $\vec{x}^*$ contains all possible determinants of y. Cramer (1969, pp. 79–83) justifies the transition from (1.1) to a linear function

$$y = \beta_0 + \vec{x}'\vec{\beta} + u, \tag{1.2}$$

with $\beta_0, \vec{\beta}$ the coefficients and u the error term, by regarding (1.2) as the Taylor approximation of (1.1) around the averages of the values of y and $\vec{x}$ in the observation period. All variables of $\vec{x}^*$ that are constant in this period are (*inter alia*) included in $\vec{\beta}_0$ while those variables of $\vec{x}^*$ that are not relevant or not measurable, are summarized in the error term. Hence $\vec{x}$ is a subset of $\vec{x}^*$ with $\vec{\beta}$ the partial derivatives of ϕ with respect to $\vec{x}$.

Apart from the problem of selecting $\vec{x}$ from $\vec{x}^*$ and the problem of measuring the variables in $\vec{x}$, which in practice comes down to selecting one variable at a time from a vast list of possible ones, see e.g. Bierens (1980), and the fact that the ordinary least squares estimator of the slope of ϕ does not necessarily coincide with the Taylor approximation (White, 1980), the transition from (1.1) to (1.2) needs some further assumptions as follows.

(i) The deviations of $\vec{x}$ from their averages and/or derivatives of second and higher order are sufficiently small.
(ii) The partial derivatives of higher order in respect of $\vec{x}$ and the irrelevant determinants are zero.

Obviously, for each empirical specification of a regression equation, the above assumptions, possibly after an adequate transformation of the data, should be approximately met. Moreover, when we estimate the equation, additional assumptions on the error term should be made. Such technical (or statistical) arguments play an important part in specifying a regression equation. We dispose of a vast and ever-growing store of statistical techniques and tests in order to meet or check the required assumptions for regression analysis. Some of these tests are standard output in regression computer programs and their outcomes often lead to a revision of the specification.

On the other hand theoretical reasoning (based on economic theory, in our orientation) precedes the regression analysis and may determine the specification to a considerable degree, or may at least establish a number of conditions for the specification to meet; see however Sims (1980, 1982) and also Lucas & Sargent (1978) for an opposing view.

In actual empirical economic model building the statistical and economic arguments may conflict. In fact, if too much emphasis is laid on statistical arguments a regression equation may result which has no plausible economic interpretation. Otherwise, economic theory should not imply such rigid specification as to render a statistically adequate estimation impossible.

This paper critically reviews a number of statistical and theoretical arguments in the specification problem from the point of view of econometric practitioners. With respect to questions (2) and (3) raised earlier, special attention is paid to two specific problems of choice in actual model building, namely whether or not the equation has to be specified in first differences and/or in logarithms. The next section deals with statistical arguments and § 3 with economic arguments. Section 4 summarizes the specification of equations in a number of macro-economic models. Section 5 contains a summary and the conclusions of this paper.

2 Statistical arguments

2.1 *Linear or loglinear*

In the introduction it appears that the second and higher order partial derivatives in the Taylor approximation should be small. This is, of course, not the case when the relation between y and $\vec{x}$ is multiplicative. In that case a logarithmic transformation is in order. Obviously such a transformation is possible for variables with positive values only.

In the literature one often encounters the *ad hoc* statistical argument for a logarithmic transformation that it will avoid a certain trend-like form of heteroscedasticity of the error terms; see e.g. Gaudry & Dagenais (1979). This argument refers to relationships in which high values of $\vec{x}$ imply high values of y, while the stochastic shocks with those observations are also relatively large. In that case the error term is added multiplicatively:

$$y = \beta_0\Big(\prod_i x_i^{\beta_i}\Big)u,$$

with x_i and β_i the elements of $\vec{x}$ and $\vec{\beta}$. There may be good reasons for specifying the error term with a logarithmic transformation in this way, e.g. when omitted variables are the source of the stochastic process. It is by no means a matter of course, however, that in case of a multiplicative specification the error term is added multiplicatively. For example, measurement errors in the dependent variable may lead to an additive error term (with respect to the original model):

$$y = \beta_0\Big(\prod_i x_i^{\beta_i}\Big) + u.$$

It should be noted that heteroscedasticity of the disturbances should not in itself be the argument for specifying the regression in logarithms, as in estimating it is possible to take it into account.

If there are no *a priori* reasons for a linear or logarithmic functional form, the choice may be determined with the help of the (generalized) Box & Cox (1964) transformation, where

$$y^{(\lambda)} = \sum_i \beta_i x_i^{(\lambda_i)} + u, \tag{2.1}$$

with

$$y^{(\lambda)} = (y^{\lambda} - 1)/\lambda, \quad x_i^{(\lambda_i)} = (x_i^{\lambda_i} - 1)/\lambda_i.$$

Given normality of the error terms, the λ's can be estimated with the maximum likelihood method, with estimates around one indicating a linear specification, and estimates near zero indicating a logarithmic specification. This transformation was applied to the U.S. demand for money function by Zarembka (1968) in a simple form, with the same λ for the dependent variable and all explanatory variables. In a more general form it has been used in empirical economic research by, for instance, Tsao (1975) (consumption function), White (1972), Spitzer (1976) (demand for money and liquidity trap), Spitzer (1977) (a system of simultaneous equations in money demand and interest rates), Broekhuis (1977) (Engel curve) and Berndt & Khaled (1979) (production functions).

Apart from the question whether or not λ should differ per variable, the way of adding the error term and the assumptions on it have important consequences for the estimation procedure as well as for the estimation results; see Zarembka (1974) and Leech (1975). Den Butter & Kuné (1976), however, show the difference in results for the Netherlands demand for money function when the disturbance term is added before or after the transformation, to be rather small. Savin & White (1978), Gaudry & Dagenais (1979) and Lahiri & Egy (1981) consider the technicalities in the case of general assumptions about the error term, while Mallela (1980), Huang & Grawe (1980) and Poirier (1980) discuss the estimation problems because of nonnormality of the error when $\lambda \neq 0$.

Besides estimating the value of the λ's, which may yield a functional form somewhere in between a linear and a logarithmic one, the Box–Cox transformation also provides a test of the linear or logarithmic specification. The ratio between the value of the likelihood function at its maximum and the value for $\lambda=0$ or $\lambda=1$ indicates whether λ differs significantly from 0 or 1; see e.g. Savin & White (1978). A problem of interpretation of this likelihood ratio test is that the choice linear versus logarithmic ($\lambda=1$ against $\lambda=0$) is not directly tested. Thus it may happen that both $\lambda=1$ and $\lambda=0$ are rejected (or accepted) by the test. On the other hand, the test by Aneuryn-Evans & Deaton (1980) and the Lagrange multiplier tests by Godfrey & Wickens (1981) and Poirier & Ruud (1979) directly compare a linear with a logarithmic specification.

2.2 Levels or first differences

Yule (1926) already pointed to the danger of trend correlation in regression analysis when both the dependent variable and one (or more) explanatory variable(s) are monotonicly increasing (or decreasing). This provides an *ad hoc* argument for taking first differences. A related argument is that multicollinearity among explanatory variables is avoided. A more basic argument for differencing is to obtain a stationary model; see Harvey (1981, p. 12).

In principle, the question whether or not a regression is to be specified in differences forms part of the more general problem of the specification of the lag structure. Box & Jenkins (1970) provide a procedure for specifying and estimating the lag structure in a transfer function. The general form of the so-called multiple input transfer function model is:

$$y=\beta_0+\sum_i \beta_i \frac{\omega_i(B)}{\delta_i(B)} B^{d_i} x_i+\frac{\theta(B)}{\phi(B)} a, \tag{2.2}$$

where $\delta_i(B)$, $\omega_i(B)$, $\theta(B)$ and $\phi(B)$ are polynomials in the lag operator $B(Bz_t=z_{t-1})$ such that

$$\delta_i(B)=1-\delta_{i1}B-\delta_{i2}B^2-\ldots-\delta_{ir_i}B^{r_i}, \quad \omega_i(B)=1-\omega_{i1}B-\omega_{i2}B^2-\ldots-\omega_{is_i}B^{s_i},$$
$$\theta(B)=1-\theta_1 B-\theta_2 B^2-\ldots-\theta_q B^q, \quad \phi(B)=1-\phi_1 B-\phi_2 B^2-\ldots-\phi_h B^h;$$

the d_i's are positive integers reflecting the period of pure delay or dead time before the response to a given input begins to take effect; a is white noise obtained from filtering the error terms with $\phi(B)/\theta(B)$.

The Box & Jenkins procedure distinguishes three stages. In the identification stage, after an optional logarithmic or Box–Cox transformation of $\vec{x}$ and y, the polynomials $\delta_i(B)$, $\omega_i(B)$, $\theta(B)$ and $\phi(B)$, and the values of d_i are determined. The use of the Box–Cox transformation in this state is advocated by Box & Jenkins (1973); Jenkins (1979, p. 95) has built it as a standard option into his computer program. However Chatfield & Prothero (1973), Nelson & Granger (1979) and Poirier (1980) advise against its use. After the identification stage comes the estimation stage, in which all coefficients are estimated, and the stage of diagnostic checking, in which the statistical adequacy of the model is tested.

For the specification problem the identification stage is most important. This stage determines whether the explanatory variables and the dependent variable are transformed to first differences or even higher order differences. In order to identify the form of the polynomials, according to Box and Jenkins's prescription, each explanatory variable has to be transformed into white noise by means of an appropriate filter or ARIMA (autoregressive integrated moving average) model. In the case of growth series, which are much used in empirical economic research, it appears to be nearly always necessary to take first, and often second differences when constructing these ARIMA models. Strong seasonal fluctuations may necessitate a so-called seasonal difference ($\Delta_4=1-B^4$).

For the specification of the transfer function model this may lead to the following problem. Economic theory establishes in what way the variables influence one another. In the consumption function, for example, the level of consumption is influenced by income, but not (exclusively) by changes in income. In a transfer function model for consumption, therefore, the *same number* of differences should be taken for all variables. This requirement may conflict with the results of the Box–Jenkins prescription.

A practical disadvantage of not analogously differencing all variables in a regression equation is that it leads to intricate lag structures and, moreover, that it makes interpretation more difficult. An example is Den Butter's (1979) analysis of the impact of monetary impulses on the increase of national income, where for liquidity creation a seasonal difference has been taken, whereas the increase of income and the foreign monetary impulse read in ordinary first differences. Seasonal fluctuations are better described by seasonal dummies than by seasonal differences. For example, studies by Fase (1980) and Den Butter & Fase (1982) show that when seasonal dummies are used, seasonal differences can be dispensed with, and that a moving seasonal pattern, if any, can be described by the relevant parameters of the ARMA (autoregressive-moving average) model of the error term.

Thus, the Box–Jenkins prescription does not give a definite answer to the problem of differencing in regression analysis, albeit that the identification procedure will in general lead to a specification of the main macro-economic relationships (demand for money function, consumption function, investment function, import and export functions) in first and often even in second differences, by which trend correlation is avoided.

This automatic taking of first or second differences should be objected to for economic as well as for technical reasons; see Plosser & Schwert (1978) and the discussion between Courakis (1978), Hendry & Mizon (1978) and Williams (1978). Taking first differences in equation (2.2) may rest on the assumption that the polynomials $\delta_i(B)$ and $\phi(B)$ can be decomposed as follows:

$$\delta_i(B) = (1-B)\delta_i'(B), \quad \phi(B) = (1-B)\phi'(B). \tag{2.3}$$

In other words, all these polynomials have the common root $B=1$. This common root implies restrictions on the coefficients of the polynomials. These restrictions should be tested.

On the other hand, when a specification with a stationary error term is desired, differencing may be necessary all the same. In that case differencing is to be considered as a *filter* and not as a set of restrictions on the coefficients. In doing so (2.2) is transformed as follows, for $\Delta = 1-B$:

$$\Delta y = \sum_i \beta_i \frac{\omega_i(B)}{\delta_i(B)} B^{d_i} \Delta x_i + \frac{\theta(B)}{\phi(B)} \Delta a. \tag{2.4}$$

Harvey (1980) points to the danger of proceeding too quickly to differencing for the sake of stationarity. From his Monte Carlo study with (relatively) small samples it appears hard to discriminate between a model with a random walk error term:

$$\Delta u = a$$

or a model with a first-order autoregressive error term with an autoregression parameter of for example 0.9:

$$(1-0.9B)u = a.$$

In principle the Box–Jenkins time-series analysis proceeds from a general to a specific form. Box & Jenkins recommend keeping the length of the polynomials in equation (2.2) as short as possible, so as to limit the number of parameters to be estimated (principle of parsimony).

On the other hand in the so-called specification analysis of Hendry, Mizon and others (Mizon, 1977; Davidson, *et al.*, 1978; Mizon & Hendry, 1980) one starts by formulating a stochastic difference equation containing as many parameters as possible and variables and reflecting all *a priori* knowledge obtained from both theory and earlier empirical results. For a justification of this method, which in this respect clearly opposes the Box–Jenkins method, see Palm (1981) and Harvey (1981, pp. 280–281). Here the cycle of identifying, estimating and diagnostic checking is not traversed and no start is made on a parsimonious model. However, the successive rejections of null hypotheses against alternative hypotheses imposing restrictions on the parameters may reduce the number of parameters to be estimated. These alternative hypotheses may contain both empirical restrictions, such as the common roots in equation (2.3), i.e. the so-called 'common factor' (COMFAC) approach (Sargan, 1964), and theoretical restrictions, such as adaptive expectations, distributed lags etc. In general this specification analysis leads to less differencing than the Box–Jenkins procedure.

In the literature the above mentioned tests are often called specification tests. In addition there are the so-called misspecification tests. They examine whether, for statistical or economic arguments, a more general form would not be more satisfactory than the simple specification to start with. Examples of misspecification tests are the Durbin–Watson test and the Lagrange multiplier tests; for a review, see Breusch & Pagan (1980). In these tests the null hypothesis is a model with a simple structure that is tested against the alternative hypothesis of a model with a more general structure, where the simple model is nested with respect to the more general model. A characteristic of these misspecification tests is that the more general hypothesis need not be estimated. Such tests are useful, for example, when a model which is linear in parameters and which therefore can be simply estimated with ordinary least squares, is compared with the same model having an additional nonlinear parameter. The test statistic then is a function of the (ordinary least squares) residuals of the simple model and can thus easily be derived. Hence, nonlinear estimation will be necessary only if the null hypothesis is rejected.

Specification and misspecification tests proceed from diametrically opposed research strategies. But they do not exclude each other. Both the analysis of transfer functions (Box & Jenkins) and the specification analysis end with misspecification tests in order to investigate the adequacy of the finally selected model.

3 Economic arguments

3.1 Linear or log linear

An important economic consequence of a linear specification is that the (marginal) ratio between the dependent variable and each of the explanatory variables, is assumed to be constant. A linear consumption function for instance implies a constant marginal consumption ratio. Moreover, at a positive value of the constant term the average consumption ratio will decrease, whereas at a negative constant it will increase. A logarithmic specification on the other hand implies constant elasticities and consequently changing ratios. For instance, in a logarithmic demand for money function the income elasticity and interest rate elasticity are assumed to be constant whereas at the same time there is interaction between the explanatory variables. It implies that if income increases but the interest rate remains unchanged, the effect of the interest rate on the demand for money will increase. With a linear specification there is no such interaction, that is if there is no scaling of explanatory variables.

The foregoing shows how economic arguments may lead to a choice between a linear and a logarithmic specification. In utility functions and production functions interaction between the dependent variables is a vital assumption. Here a linear specification cannot be used. Another example of economic arguments leading to a specific functional form are Engel curves, which measure the impact of income on the consumption pattern. Here a distinction is made between luxury goods and necessities. The latter's share in total consumption will be high at a low income, but decline at a rising income. The case of declining income elasticity is well reflected by a semi-logarithmic function, in which consumption of the good is specified as a function of the logarithm of income.

In the previous section it was stated that if no *a priori* choice can be made between a linear and a (semi) logarithmic specification, the (generalized) Box–Cox transformation can be applied. A restricted estimation of (2.1) (where for all $i:\lambda_i=0$ or 1, or $\lambda_i=\lambda$) however does not under all circumstances yield economically plausible values (Gemmill, 1980). Suppose, for instance, that (2.1) represents demand for a necessity (though not an inferior good), where x_1 represents income and x_2 the price of the good. Theoretically the income elasticity, say E_1, will decrease if at the given price income increases. Equally, the price elasticity, say E_2, will at a given income increase if the price rises. If we assume that $0<E_1<1$ and $E_2<0$, it then appears that a linear or logarithmic specification of the demand equation is at variance with the theory described. Moreover, the rather prohibitive restriction $\lambda<0$ should hold for the often applied simple form of the Box–Cox transformation where all λ's are equal to each other.

On the whole the theory of consumer behaviour abounds with examples in which economic arguments determine which variables ought to be included in a demand equation and what restrictions the coefficients in a system of demand equations should meet. Although the contribution of the theory often is rather general, yet it may lead to a very specific model structure, such as, for example, the linear expenditure system (Stone, 1954), the Rotterdam model (Theil, 1967; Barten, 1969), the model of Somermeijer (Somermeijer & Langhout, 1972), the trans-log model (Christensen, Jorgenson & Lau, 1975) and the semi-logarithmic system of demand equations of Deaton & Muellbauer (1980).

3.2 Levels or first differences

Section 2 describes how for statistical reasons the Box & Jenkins time-series analysis and the specification analysis may lead to specifications in first or even higher order differences. Box & Jenkins, in addition, offer a recipe for determining the whole lag structure. Such a recipe is useful in the (many) cases in which economic theory does not prescribe the form of the lag structure. Yet, economic theory sometimes does offer a starting point for the specification of the lags in a regression equation. The two best known examples are the hypotheses of partial adjustment and of adaptive expectations.

With partial adjustment the desired value of the dependent variable y^* is supposed to be a function of the explanatory variables, and the actual value of y is assumed to adjust to the desired value with the fraction $(1-\delta)$ per time unit $(0<\delta<1)$.

$$y_t = y_{t-1} + (1-\delta)(y_t^* - y_{t-1}).$$

In equation (2.2) this assumption leads to

$$\delta_i(B) = \frac{1-\delta_i B}{1-\delta_i}, \quad \omega_i(B) = 1.$$

With adaptive expectations the dependent variable is a function of the expected values of the explanatory variables (x^*_{it}) rather than the actual values. These expected values are assumed to adapt to the expectation errors in the preceding period:

$$x^*_{it} = x^*_{it-1} + (1-\omega_i)(x_{it} - x^*_{it-1}).$$

Here the average lag is $(1-\omega_i)/\omega_i$ while for equation (2.2)

$$\omega_i(B) = \frac{1-\omega_i}{1-\omega_i B}, \quad \delta_i(B) = 1.$$

In most cases, however, the lag structure will be determined completely by the data. Economic theory, on the other hand, often prescribes whether or not the regression equation should be specified in differences. If, for example, a demand for money function is based on the portfolio theory, a specification in levels will be required for this function, i.e. with the money stock as the dependent variable and not the changes in (or growth of) the money stock. In that case only nonstationarity of the model may be a reason for differencing in the sense of equation (2.4).

Den Butter & Fase (1981) show, however, that after estimation of the demand for money functions for E.E.C. countries in levels, the residuals of each of these equations appear to be stationary. When applying the Box–Jenkins procedure, all these equations should read in second differences, as tried out. Then even the estimated effect of income, which is according to economic theory the most important determinant of the demand for money, appears to be absent. This corresponds, by the way, with the results of causality tests, where time-series are filtered by means of ARIMA-models; see e.g. Feige & Pearce (1979), Williams, Goodhart & Gowland (1976), Dyreyes, Starleaf & Wang (1980) and Fase (1981).

The specification analysis of Hendry, Mizon and others recommends checking the plausibility of the equilibrium resulting from the selected dynamic regression equation. Here economic theory may provide guidelines for judging the estimation results. In order to make a derivation of the equilibrium relation possible it is required that the dynamic regression equation should be specified in levels. An additional inclusion of first differences as explanatory variables in the equation may help to describe the adjustment mechanism in the case of deviations from the equilibrium. Specifying solely in first differences, however, means that the information about the equilibrium will be lost. This loss of information is even greater with second order differences. In that case the information about the equilibrium growth path is lost and the regression equation will solely describe the oscillation around this growth path. As a result such equations are only useful for making predictions a few periods ahead. Forecasts of a large number of periods ahead tend to run away from the realized level.

Another example of theory prescribing whether or not a relation is to be specified in levels and/or first differences can be found in the case of consumer demand. The demand for durable consumer goods can be split into a net demand and a replacement demand due to depreciation. If it is assumed (Garcia dos Santos, 1972) that such depreciations are a function of both the existing stock of durables and also of new purchases, as in the course of the current period part of these new purchases is already being depreciated, not only the levels of the explanatory variables (price, income) but also the first differences of these variables enter the specification of the demand equation. For nondurables such a distinction between stock and flow is not relevant. Hence, from this angle there is a difference between the specification of the demand for durables and the demand for nondurables.

An analogous phenomenon occurs with the demand for long-term and short-term funds. Short-term funds are so to speak (entirely) consumed during each observation period, whereas with long-term funds only a part of the stock has to be replaced. Hence in the case of short-term funds a portfolio approach with the level as the dependent variable is called for (Fase, 1979), whereas with long-term funds changes in the level representing demand should be preferred; see e.g. Den Butter, Dongelmans & Fase (1977).

4 Specification in a number of macro-economic models

Table 1 shows the characteristics of a number of macro-economic models. We investigated in what way the model equations were specified and with what arguments. Our selection of macro-economic models has partly been inspired by the history of model building and partly by our orientation towards monetary macro-economics.

Tinbergen's (1936, 1939) pioneering work is at the basis of the tradition of model building both in the Netherlands and in the United States. Tinbergen's models are specified in percentage changes, with the argumentation that the models aim to explain the trade cycle. Therefore only the deviations of the variables from their trend are relevant. This and some additional arguments (the algebraic form of the equations can be kept simple, multicollinearity is removed, pre-war data can be linked better to postwar data) have, for a long time, induced the Dutch Central Planning Bureau (C.P.B.) to specify all equations of their models in percentage changes; see e.g. C.P.B. (1955), Verdoorn (1967), C.P.B. (1971). Only recent models (Driehuis, 1972; Vintaf II in C.P.B., 1977) specify a number of their equations in levels.

The wage and price equations, however, read in percentage changes in almost all models that we investigated. The argumentation (Buiter & Owen, 1979) is based on the Keynesian rigidity of wages and prices, so that a regression equation can only describe the changes in these variables by disequilibria in the markets.

Apart from Tinbergen's (1939) model the early U.S. models are mainly specified in levels (Klein, 1950, model I; Klein & Goldberger, 1955; Goldfeld, 1966; Brookings, see Duesenberry *et al.*, 1965; Wharton, see Evans & Klein, 1968) or in first differences (Suits, 1962, F.R.B.–M.I.T., see De Leeuw & Gramlich, 1968).

It is remarkable that, in spite of the developments in computer technology, only a few nonlinear specifications are encountered in recent models, notably Fair (1976) and Vintaf II (C.P.B., 1977).

Scaling (or a ratio specification) often occurs with respect to monetary quantity variables. Such specifications are homogeneous of the first order in relation to the scale variable which often represents income or (financial) wealth. Examples of this specification in Dutch models are given by Driehuis (1972), Van Loo (1974) and Knoester (1980), and in foreign models by Vuchelen (1976), in RDX2, described by Helliwell *et al.* (1971) and Bank of England (1979).

5 Summary and conclusions

This paper considers the specification problem in economic model building from the point of view of econometric practitioners. In specifying a regression equation two important problems of choice are those between:

(a) a linear and a log linear specification
(b) a specification in levels and in first (or higher order) differences.

Table 1

Specification in macro-economic models

Model	Specification	Statistical arguments	Economic arguments
Tinbergen (1936) (Netherlands)	% changes		Only explanation of trade cycle is important
Tinbergen (1939) (U.S.)	% changes		As Tinbergen (1936)
Klein (1950) (U.S.)	Linear in levels		Linear approx. to unknown utility or production function
C.P.B. (1955) (Netherlands)	% changes	Algebraic form can be kept simple	
Klein & Goldberger (1955) (U.S.)	Linear in levels		
	% changes (money market interest rate)		Change will occur only if there is excess supply or demand on money market
	Nonlinearities (liquidity preference)		Keynesian distinction between transactions proportional to income and speculation balances which are semi-logarithmic function of interest rate levels
Suits (1962) (U.S.)	Linear in first differences	Effect of slowly changing variables eliminated; less sensitive to data revisions	For durable goods addition to stock alone is relevant
Verdoorn (1967) C.P.B. 63-D (Netherlands)	% changes	Reduces multicollinearity; pre-war data can be linked better to post-war	
	Nonlinearities (utilization rate)		Phillips curve effect
Duesenberry *et al.* (1965), Brookings (U.S.)	All possible kinds of specs.		Various arguments
Goldfeld (1966) (U.S.)	Linear in levels	Validity of log linear or ratio specifications against linear ones for eqs. of banking system is tested by examining validity of usual assumptions with respect to error terms	
	Nonlinearities (demand for money functions)		Due to theoretical stock approach (Baumol, 1952; Tobin, 1956)
Van den Beld (1968) (Netherlands)	% changes	Reduces multicollinearity; facilitates estimation of time lags	
	Linear in levels (consumption, investment, imports and exports)		
	Linear in first differences (labour supply, inventory formation, creation of liquidities)		
	Nonlinearities (utilization rate)		As Verdoorn (1967)

Table 1 (contd)

Model	Specification	Statistical arguments	Economic arguments
Evans & Klein (1968), Wharton (U.S.)	Linear in levels		
	Log linear in levels (capacity eqns.)		Based on Cobb–Douglas production function
	Linear in first differences (prices and wages)		
De Leeuw & Gramlich (1968); F.R.B.–M.I.T. (U.S.)	Linear in levels		
	Linear in first differences (some interest rates, demand for loans; housing starts)		
	Log linear in levels (some demand for financial assets eqns.)		
	Ratio spec. (time deposits)		
	% changes (rent)		
C.P.B.-1969 (1971) (Netherlands)	% changes	As previous C.P.B. models	
	Nonlinearities (utilization rate)		As previous C.P.B. models
Helliwell *et al.* (1971) Bank of Canada, RDX2 (Canada)	Linear in levels		
	Log linear in levels (export eqns)		
	Nonlinearities (production block)		Due to production function used
	Ratio spec. (monetary variables)		
	Nonlinearities (demand of liquid assets)		Due to inclusion of budget constraint
Driehuis (1972) (Netherlands)	Log linear in levels	No constant relationship between absolute value of variables Reduction of heteroscedasticity	Derived from Cobb–Douglas production function
	% changes (labour supply, wages and prices)		Derived from theoretical nonlinear functions
Van Loo (1974) (Netherlands)	Linear in levels with ratio spec. of dependent variable		Homogeneity with respect to scale variable
Fair (1976) (U.S.)	Log linear in levels		Resulting from combining constrained and unconstrained results of optimal behaviour by decision units
	Linear in first differences (investment)		
	Linear in levels (interest paid by firms, inventory formation, capital gains on stocks)		
	Nonlinearities	Due to removing of serial correlated error terms	

Table 1 (contd)

Model	Specification	Statistical arguments	Economic arguments
Vuchelen (1976) (Belgium)	Linear or log linear in levels Ratio spec. of dependent variables (in demand for assets by private and banking sector)		As Van Loo (1974)
Korteweg & Van Loo (1977) (Netherlands)	% changes of monetary variables measured in real terms Linear in first differences (interest rate eqn.)		Desired holdings of assets are homogeneous of degree zero in price level
Deutsche Bundesbank (1978) (Germany)	% changes	Solely deviations from trend count	
Bank of England (1979) (U.K.)	All possible kinds of spec.		
Banca d'Italia (1979), M2BI (Italy)	Linear or log linear in levels Linear in first differences (some monetary equations)		Based on stock adjustment
Knoester (1980) (Netherlands)	% changes Linear in levels with ratio spec. of dependent variables (in demand for assets by banking system)	As former C.P.B. models	As former C.P.B. models As Van Loo (1974)

C.P.B., Dutch Central Planning Bureau; F.R.B.–M.I.T., Federal Reserve Bank–Massachusetts Institute of Technology.

Both statistical-technical arguments and economic theoretical considerations may contribute in choosing between the alternatives.

Table 2 gives a summary of some *ad hoc* arguments found in the literature. The builders of macro-econometric models often reproduce these arguments when justifying the specification of their models. On the other hand, in a number of models the specification is merely postulated without further argument.

When there are no *a priori* reasons for a choice between the alternatives in Table 2, the specification can be determined empirically. The Box–Cox transformation discriminates between a linear and a logarithmic specification, while Harvey's (1980) test indicates whether differencing is necessary or not. Both problems of choice could be tackled together with the help of an analogue of the Savin & White (1978) test.

The two above alternatives are, of course, only part of the specification problem. In fact, the problem of choosing the functional form in general can be solved by the method of testing nonnested models, proposed by Pesaran (1974) and Pesaran & Deaton (1978), while the transfer function method of Box & Jenkins, and the specification analysis of Hendry, Mizon and others provide a more general approach to the second problem of choice. Both last methods form a kind of recipe according to which the regression crystallizes to its final specification.

Although the choice of specification is not completely effected algorithmically and there

Table 2
Ad hoc arguments for the specification problem

Specification	Statistical arguments	Economic arguments
Linear spec.	Observations with negative values	Constant marginal ratio No interaction between explanatory variables
Log linear spec.	Avoiding heteroscedasticity Multiplicative adding of error term	Constant elasticity Interaction between explanatory variables
Specification in levels	Model is already stationary	Adjustment of stocks (portfolio theory) Long-term equilibrium of stock should follow from regression eqn.
Specification in (first) differences	Avoiding trend correlation Avoiding multicollinearity Obtaining stationary model Data revisions and breaks of series have little effect	Additions to stock alone are important

remains some scope for specific arguments, the Box & Jenkins method in particular is a strong mechanical procedure in which statistical arguments prevail. This is less so with the Hendry & Mizon specification analysis, where economic arguments and a scrutiny of the data as given by Davidson *et al.* (1978) may also contribute to the choice of specification. However, as a result, the specification analysis is difficult to 'imitate'. In addition, subsequent testing of restrictions within the general form, while maintaining those restrictions if they are not rejected by the test, readily leads to a simple specification which has little practical relevance for policy making. This holds, e.g. for De Jong & Kiviet (1979) and Bloomestein & Palm (1979), where the Dutch investment function and the demand-for-money function respectively are 'Hendryfied'. In the traditional Hicksian IS-LM model nonzero interest elasticities in the IS and LM curves are essential for the transmission of a money supply based monetary policy. However, Blommestein & Palm arrive at a specification where the hypothesis of a zero interest elasticity cannot be rejected. In the finally selected specification of the De Jong & Kiviet study the elasticity of substitution between production factors equals zero, which is at variance with the facts and with (neo-classical) theory.

These examples show that in specifying a regression equation statistical measures like R^2 or the outcomes of likelihood ratio tests on nested models are not always of crucial importance. Rather than using a mechanical procedure for determining the specification one should, in such cases as mentioned above, search for alternative specifications, e.g. by a relevant transformation of some data or by adding explanatory variables which are of specific relevance in the reference period. The (possibly nonnested) alternatives then should be judged both by theoretical criteria such as sign of the effects, speed of adjustment and findings in similar empirical studies, and by statistical criteria. This importance of economic theory in macro-economic model building has been emphasized, e.g. by Somermeijer (1967), and recently again by Klein (1980). Of course, the search for a specification which fully corroborates economic theory should not degenerate into 'data mining', where statistical statements on the results will no longer hold. Fair (1980), incidentally, has recently developed a procedure with which (naive) 'data miners' can be detected.

The literature tends to overexpose statistical arguments in developing new estimation and testing techniques. Interpretable results are, however, more important to the user of econometric models than the fact that the most efficient estimation technique has been applied. This view is supported by Monte Carlo studies showing that in small samples (which is usually the case with macro-economic research) simple estimation methods are sometimes not inferior to more advanced and asymptotically most efficient methods; see e.g. Summers (1965) and Yamamoto (1979). Hence, in practical model building, and certainly when empirically undeveloped relations are concerned, much more attention is paid during the specification process to the plausibility of the results than to the estimation technique. Within certain bounds this is very well acceptable from a statistical point of view. But the result is that no hard and fast rules can be given for the specification of a regression equation, but that it will always be a form of handiwork.

Acknowledgements

The authors acknowledge the critical comments on a previous version of this paper by J.F. Kiviet, Professor F.C. Palm and their colleagues at the Bank.

References

Aneuryn-Evans, G. & Deaton, A. (1980). Testing linear versus logarithmic regression models. *Rev. Econ. Stud.* **47,** 257–291.

Banca d'Italia (1979). Modello econometrico dell'economia italiana. Rome: Banca d'Italia, Centro Stampa.

Bank of England (1979). Bank of England model of the U.K. economy, Discussion paper No. 5. London: Bank of England.

Barten, A.P. (1969). Maximum likelihood estimation of a complete system of demand equations. *Europ. Econ. Rev.* **1,** 7–73.

Baumol, W.J. (1952). The transactions demand for cash; an inventory theoretic approach. *Quart. J. Econ.* **66,** 545–556.

Beld, Van den C.A. (1968). An experimental medium-term macro model for the Dutch economy. In *Mathematical Model Building in Economics and Industry*, Ed. M.G. Kendall, pp. 34–48. London: Griffin.

Berndt, E.R. & Khaled, M.S. (1979). Parametric productivity measurement and choice among flexible functional forms. *J. Polit. Econ.* **87,** 1220–1245.

Bierens, H.J. (1980). Consistent selection of explanatory variables. *Statist. Neerl.* **34,** 141–150.

Blommestein, H.J. & Palm, F.C. (1979). Econometric specification analysis—an application to the aggregate demand for money in the Netherlands, Research memorandum 8. Amsterdam: Vrije Universiteit.

Box, G.E.P. & Cox, D.R. (1964). An analysis of transformations. *J. R. Statist. Soc.* B **26,** 211–243.

Box, G.E.P. & Jenkins, G.M. (1970). *Times Series Analysis.* San Francisco: Holden-Day.

Box, G.E.P. & Jenkins, G.M. (1973). Some comments on a paper by Chatfield and Prothero and on a review by Kendall. *J. R. Statist. Soc.* A **136,** 337–345.

Breusch, T.S. & Pagan, A.R. (1980). The Lagrange multiplier and its applications to model specification in econometrics. *Rev. Econ. Stud.* **47,** 239–253.

Broekhuis, J. (1977). The use of the Box–Cox transformation in Engel curve analysis, Mimeo. Amsterdam: De Nederlandsche Bank N.V.

Buiter, W.H. & Owen R.F. (1979). How successful has stabilization policy been in the Netherlands? A Neo-Keynesian perspective. *De Economist* **127,** 58–104.

Butter, Den F.A.G. (1979). An empirical analysis of Dutch monetarism, Paper presented at the European Meeting of the Econometric Society in Athens 1979, Research report 7810. Amsterdam: De Nederlandsche Bank N.V.

Butter, Den F.A.G., Dongelmans A.M. & Fase, M.M.G. (1977). De vraag naar hypothecair krediet en de rente-vorming op de hypotheekmarkt. *De Economist* **125,** 43–74.

Butter, Den F.A.G. & Fase, M.M.G. (1981). The demand for money in E.E.C. countries. *J. Monetary Econ.* **8,** 201–230.

Butter, Den F.A.G. & Fase, M.M.G. (1982). Forecasting the money stock in 6 E.E.C. countries. In Proceedings of the VIth International Conference on Applied Econometrics. Paris: Economica. To appear.

Butter, Den F.A.G. & Kuné, J.B. (1976). De functionele vorm van de geldvraagvergelijking in Nederland 1952:II-1971:IV. *Tijdschrift voor Economie en Management* **21,** 169–177.
Chatfield, C. & Prothero, D.L. (1973). Box–Jenkins seasonal forecasting: problems in a case study. *J.R. Statist. Soc.* A **136,** 295–315.
Christensen, L.R., Jorgenson, D.W. & Lau, L.J. (1975). Transcendental logarithmic utility functions. *Am. Econ. Rev.* **65,** 367–383.
C.P.B. (1955). The 1955-model. In *Scope and Methods of the Central Planningbureau*, pp. 20–29. Den Haag: Staatsdrukkerij.
C.P.B. (1971). Het jaarmodel 1969. In *Centraal Economisch Plan*, pp. 181–201. Den Haag: Staatsdrukkerij.
C.P.B. (1977). Een macro model voor de Nederlandse economie op middellange termijn, Occasional Paper 12. Den Haag: Centraal Plan Bureau.
Courakis, A.S. (1978). Serial correlation and a Bank of England study of the demand for money: an exercise in measurement without theory. *Econ. J.* **88,** 537–548.
Cramer, J.S. (1969). *Empirical Econometrics.* Amsterdam: North-Holland.
Davidson, J.E.H., Hendry, D.F., Srba, F. & Yeo, S. (1978). Econometric modelling of the aggregate time-series relationship between consumers expenditure and income in the United Kingdom. *Econ. J.* **88,** 661–692.
Deaton, A. & Muellbauer, J. (1980). An almost ideal demand system. *Am. Econ. Rev.* **70,** 312–326.
Deutsche Bundesbank (1978). Further development of the econometric model of the Deutsche Bundesbank. *Mon. Rep. of Deutsche Bundesbank* **30,** 22–31.
Driehuis, W. (1972). *Fluctuations and Growth in a Near Full Employment Economy.* Rotterdam University Press.
Duesenberry, J.S., Fromm, G., Klein, L.R. & Kuh, E. (1965). *The Brookings Quarterly Econometric Model of the United States.* Amsterdam: North-Holland.
Dyreyes, F.R., Starleaf, D.R. & Wang, G.H. (1980). Test of the direction of causation between money and income in six countries, *Southern Economic Journal* **47,** 477–487.
Evans, M.K. & Klein, L.R. (1968). The Wharton econometric forecasting model. Philadelphia: Univ. Pennsylvania.
Fair, R.C. (1976). *A Model of Macro-economic Activity.* Cambridge: Ballinger.
Fair, R.C. (1980). The effects of misspecification on predictive accuracy. Paper presented at the international symposium on criteria for evaluating the reliability of macro-economic models. University of Pisa.
Fase, M.M.G. (1979). The demand for bank credit and the commercial bank lending rate: an econometric analysis for the Netherlands, Research report 7710. Amsterdam: De Nederlandsche Bank N.V.
Fase, M.M.G. (1980). Monetary base control: a useful alternative for the Netherlands? *De Economist* **128,** 189–204.
Fase, M.M.G. (1981). *Op het Breukvlak van Macro- en Micro-Economie.* Leiden: Stenfert Kroese.
Feige, E. & Pearce, D.K. (1979). The casual causal relationship between money and income: some caveats for time series analysis. *Rev. Econ. Statist.* **61,** 521–533.
Garcia dos Santos, J. (1972). Estimating the durability of consumers' durable goods. *Rev. Econ. Statist.* **54,** 475–479.
Gaudry, M.J.I. & Dagenais, M.G. (1979). Heteroscedasticity and the use of Box–Cox transformations. *Econ. Letters* **2,** 225–229.
Gemmill, G. (1980). Using the Box–Cox form for estimating demand: a comment. *Rev. Econ. Statist.* **62,** 147–148.
Godfrey, L.G. & Wickens, M.R. (1981). Testing linear and log-linear regressions for functional form. *Rev. Econ. Stud.* **48,** 487–496.
Goldfeld, S.M. (1966). *Commercial Bank Behavior and Economic Activity.* Amsterdam: North-Holland.
Harvey, A.C. (1980). On comparing regression models in levels and first differences. *Int. Econ. Rev.* **21,** 707–720.
Harvey, A.C. (1981). *The Econometric Analysis of Time Series.* Oxford: Philips Allan.
Helliwell, J.F., Shapiro, H.T., Sparks, G.R., Stewart, I.A., Gorbet, F.W. & Stephenson, D.R. (1971). *The Structure of* RDX2. Ottawa: Bank of Canada.
Hendry, D.F. & Mizon, G.E. (1978). Serial correlation as a convenient simplification, not a nuisance: a comment on a study of the demand for money by the Bank of England. *Econ. J.* **88,** 549–563.
Huang, C.J. & Grawe, O.R. (1980). Functional forms and the demand for meat in the United States, a comment. *Rev. Econ. Statist.* **62,** 144–146.
Jenkins, G.M. (1979). *Practical Experiences with Modelling and Forecasting Time Series.* St. Helier: Gwilym Jenkins.
Jong, De Ph. R. & Kiviet, J.F. (1979). Macro-economische investeringsvergelijkingen, gebaseerd op Jorgensons model, voor Nederland getoetst. In *Samenleving en Onderzoek*, Eds. J.J. Klant, W. Driehuis and H.J. Bierens, pp. 183–208. Leiden: Stenfert Kroese.
Klein, L.R. (1950). *Economic Fluctuations in the United States, 1921–1941.* New York: Wiley.
Klein, L.R. (1980). Economic theoretic restrictions in econometrics, paper presented at the international symposium on criteria for evaluating the reliability of macro-economic models. University of Pisa.
Klein, L.R. & Goldberger, A.S. (1955). *An Econometric Model of the United States, 1929–1952.* Amsterdam: North-Holland.
Knoester, A. (1980). *Over Geld en Economische Politiek.* Leiden: Stenfert Kroese.
Korteweg, P. & Loo, P.D. van (1977). *The Market for Money and the Market for Credit.* Leiden: Martinus Nijhoff.

Lahiri K. & Egy, D. (1981). Joint estimation and testing for functional form and heteroscedasticity. *J. Econometrics* **15,** 299–307.

Leech, D. (1975). Testing the error specification in non-linear regression. *Econometrica* **43,** 719–725.

Leeuw, De F. & Gramlich, E. (1968). The Federal Reserve-MIT econometric model. *Federal Reserve Bull.* **54,** 11–40.

Loo, van P.D. (1974). A monetary submodel for the Dutch economy: some preliminary results. *De Economist* **122,** 89–128.

Lucas, R.E. & Sargent, T.J. (1978). After Keynesian macro-economics. In *After the Phillips curve: Persistence of High Inflation and High Employment,* pp. 49–72, Conference Series no. 19. Federal Reserve Bank of Boston.

Mallela, P. (1980). Discrimination between linear and logarithmic forms; a note. *Rev. Econ. Statist.* **62,** 142–144.

Mizon, G.E. (1977). Model selection procedures. In *Studies in Modern Economic analysis,* Eds. M.S. Artis and A.R. Nobay, pp. 90–100. Oxford: Blackwell.

Mizon, G.E. & Hendry, D.F. (1980). An empirical application and Monte Carlo analysis of tests of dynamic specification. *Rev. Econ. Stud.* **47,** 21–45.

Nelson, H.L. & Granger, C.W.J. (1979). Experience with using the Box–Cox transformation when forecasting economic time series. *J. Econ.* **10,** 57–69.

Palm, F.C. (1981). Structural econometric modelling and time series analysis; towards an integrated approach, Research memorandum 4. Amsterdam: Vrije Universiteit.

Pesaran, M.H. (1974). On the general problem of model selection. *Rev. Econ. Stud.* **41,** 92–99.

Pesaran, M.H. & Deaton, A.C. (1978). Testing non-nested non-linear regression models. *Econometrica* **46,** 677–694.

Plosser, C.I. & Schwert, G.W. (1978). Money, income and sunspots: measuring economic relationships and the effects of differencing. *J. Monetary Econ.* **4,** 637–660.

Poirier, D.J. (1980). Experience with using the Box–Cox transformation when forecasting economic time series. *J. Econometrics* **14,** 277–280.

Poirier, D.J. & Ruud, P.A. (1979). A simple Lagrange multiplier test for lognormal regression. *Econ. Letters* **4,** 251–255.

Sargan, J.D. (1964). Wages and prices in the United Kingdom. In *Econometric Analysis for National Economic Planning,* Eds. P.E. Hart, G. Mills and J.K. Whitaker, pp. 25–54. London: Butterworths.

Savin, N.E. & White, K.J. (1978). Estimation and testing for functional form and autocorrelation. *J. Econometrics* **8,** 1–12.

Sims, C.A. (1980). Macro-economics and reality. *Econometrica* **48,** 1–48.

Sims, C.A. (1982). Scientific standards in econometric modelling, paper presented at the symposium on the developments in econometrics and related fields. Netherlands Econometric Institute.

Somermeijer, W.H. (1967). Specificatie van economische relaties. *De Economist* **115,** 1–26.

Somermeijer, W.H. & Langhout, A. (1972). Shapes of Engel curves and demand curves; implications of the expenditure allocation model applied to Dutch data. *Europ. Econ. Rev.* **3,** 351–386.

Spitzer, J.J. (1976). The demand for money, the liquidity trap and functional forms. *Int. Econ. Rev.* **17,** 220–227.

Spitzer, J.J. (1977). A simultaneous equation system of money demand and supply using generalized functional forms. *J. Econometrics* **5,** 117–128.

Stone, J.R.N. (1954). Linear expenditure systems and demand analysis: an application to the pattern of British demand. *Econ. J.* **64,** 511–527.

Suits, D.B. (1962). Forecasting with an econometric model. *Am. Econ. Rev.* **52,** 104–132.

Summers, W.H. (1965). A capital intensive approach to the small sample properties of various simultaneous equation estimators, *Econometrica* **33,** 1–41.

Theil, H. (1967). *Economics and Information Theory.* Amsterdam: North-Holland.

Tinbergen, J. (1936). Kan hier te lande, al dan niet na òverbeidsingrijpen, een verbetering van de binnenlandse conjunctuur intreden, ook zonder verbetering van onze exportpositie? *Prae-adviezen voor de Vereeniging voor de Staathuishoudkunde en de Statistiek,* pp. 62–108. Den Haag: Martinus Nijhoff.

Tinbergen, J. (1939). *Statistical Testing of Business-Cycle Theories,* **2:** *Business-cycles in the United States of America.* Geneva: League of Nations.

Tobin, J. (1956). The interest elasticity of transactions demand for cash. *Rev. Econ. Statist.* **38,** 241–247.

Tsao, C.S. (1975). The linearity property in the consumption function: estimation, tests and some related results. *Rev. Econ. Statist.* **57,** 214–220.

Verdoorn, P.J. (1967). The short-term model of the Central Planning Bureau and its forecasting performance. In *Macro Economic Models for Planning and Policy Making,* pp. 35–51. Geneva: United Nations.

Vuchelen, J. (1976). A structural quarterly monetary model for Belgium. *Cahiers Economiques de Bruxelles* **72,** 493–539.

White, H. (1980). Using least squares to approximate unknown regression functions. *Int. Econ. Rev.* **21,** 149–170.

White, K.J. (1972). Estimation of the liquidity trap with a generalized functional form. *Econometrica* **40,** 193–199.

Williams, D. (1978). Estimating in levels or first differences: a defence of the method used for certain demand for money equations. *Econ. J.* **88,** 564–568.

Williams, D., Goodhart, C.A.E. & Gowland, D.H. (1976). Money, income and causality: the U.K. experience. *Am. Econ. Rev.* **66,** 417–423.

Yamamoto, T. (1979). On the prediction efficiency of the generalized least squares model with an estimated variance-covariance matrix. *Int. Econ. Rev.* **20,** 693–705.
Yule, G.U. (1926). Why do we sometimes get nonsense correlations between time series? A study in sampling and the nature of time series. *J. R. Statist. Soc.* **89,** 1–69.
Zarembka, P. (1968). Functional form in the demand for money. *J. Am. Statist. Assoc.* **63,** 502–511.
Zarembka, P. (1974). Transformation of variables in econometrics. In *Frontiers of Econometrics.* Ed. P. Zarembka, pp. 81–104. New York: Academic Press.

Résumé

Cet article passe en revue un nombre des arguments statistiques et economique-théoretiques pour spécifier une équation de régression. L'attention se concentre sur le choix entre spécifier en niveaux et en différences du premier ordre et entre spécifier en niveaux et en logarithmes. Nous énumérons des arguments *ad hoc* pour justifier le choix de spécification que nous avons trouvés dans la littérature. Nous considérons la signification de l'analyse de séries temporelles de Box et Jenkins et de la méthodologie de Hendry, Mizon *et al.* pour le problème de spécification en niveau ou en différences. L'acceptabilité théoretique des résultats de la régression sert de mesure. C'est pourquoi nous présentons des exemples dans lesquels la théorie prescrit la forme de l'équation de régression. Finalement une énumération est présentée du choix de spécification dans un nombre de modèles macro-économiques.

[*Paper received August* 1981, *revised March* 1982]